



UNIT FOUR: THE IMMUNE SYSTEM AND BLOOD STEM CELL LINEAGE TREE

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Standards:

Biology/Life sciences

10.b. Students know the role of antibodies in the body's response to infection.

"Cells produce antibodies to oppose antigens, substances that are foreign to the body.

"Antibodies can inactivate pathogens directly or signal immune cells that pathogens are present."

10.e. Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign. "When an immune system becomes dangerous antigen or incapable of mounting an appropriate defense. This situation happens when the virus infects and destroys key cells in the immune system."

10.f. Students know the role of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system. "Phagocytes move, amoeba-like, through the circulatory system, consuming waste and foreign material, such as aged or damaged blood cells and some infectious bacteria and viruses. Two broad types of lymphocytes (a class of white blood cells) originate in the bone marrow during embryonic life."

Investigation and Experimentation

1.1. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

Goals:

- Understand the basics of the immune system and its development through hematopoietic (bloodforming) stem cells.
- Distinguish between different disorders (leukemia, lymphoma, sickle cell anemia, and HIV/AIDS).
- Recognize various treatment options for patients with diseases, specifically bone marrow transplants (HSC therapy).

Objectives:

1. Student will be able to outline the organization of the immune system and hematopoietic stem cell lineage tree.



2. Student will be able to define the types of lymphoid cells and myeloid cells and describe their general functions.
3. Student will be able to explain the relationship between components of the immune system, such as antigens and antibodies.
4. Student will be able to recognize symptoms, understand the causes, and identify the cells involved in various immune system an
5. Student will be able to describe the process of, need for, and risks associated with bone marrow transplants.



Outline of Unit Four

I. INVITATION: depending on familiarity with microscopes and previous units- choose 1 or more of these activities to begin this module

A. It's in the blood" Human blood observation (can freely view virtual microscopy images from

<http://www.bloodthevitalconnection.org/forstudents/tools.aspx#PowerPoint>

OR purchase real blood smear slides and view through light microscopes.)

1. *Materials:* light microscopes; human blood smear slides (WARDS: #93 V 6541 OR Carolina: #313158); supplemental worksheet (Appendix A) [Download supplemental worksheet](#)

2. View sample of human blood under a microscope in pairs. For each slide, draw a picture of what you see on high power and answer the following questions.

- How many different types of cells do you see?
- What do you think each type of those cells (identify by shape and/or color) does in the body?

3. Then answer the following questions.

- What is the role of blood?
- Why do you think there are different types of blood cells?

B. Feeling sick? Think, Pair, Share

1. Answer the questions below, and then discuss with a partner. Finally, share with the class.

Questions

- Think about last time you were sick. How did you know you were sick? What did you feel like? (What were your symptoms?)
- How do you make yourself feel better?
- What do you think caused you to feel this way?
- What do you think is going on in your body when you are sick? How does your body respond?

C. The 'Cell' is Right:

1. Hematopoietic stem cell lineage tree activity (Appendix B) [Download Student Worksheet and Teacher Guide](#)



- a. Teacher draws a blackboard diagram (draw outlines of lineage tree and give them names of lineages and cell types (see teacher handout).
- b. *Print large pictures of each type of cell that students will cut out and place up on the board. Each picture includes functions (see handout).*
- c. *"Price is right"- timed gameshow style- students come up and place components (pictures of cells) into the stem cell lineage tree.*

2. AP student expansion/discussion questions:

- a. Are T cells a type of stem cell? Are they more like a progenitor cell?
- b. What is the difference between a stem cell, a progenitor cell, and a mature cell type?

II. EXPLORATION:

A. Lecture: Body Basics-The Immune System

1. Lecture outline: *refer to background information for content*

- a. Brainstorm and clarify causes of disease and compare with injury: pathogens, genetics, environment, etc.
- b. What is the body's response to disease and injury? Basic organization of immune system
 - Nonspecific response (innate immunity)
 - Skin, mucous membranes, secretions
 - Myeloid leukocytes (including all phagocytic cells), proteins, inflammatory response, mast cells
 - Specific response and antigen-antibody relationship (acquired immunity)
 - Lymphocytes (B, T and plasma cells)
- c. Lymphocyte development: *use cell tree as outline*
 - Origination in bone marrow
 - Unlimited supply of hematopoietic stem cells
 - Asymmetric cell division (one daughter stays in bone marrow)
 - *Note: myeloid lineage begins and released from here*
 - Differentiation into lymphoid stem cells in the bone marrow
 - General B cells mature in the bone marrow
 - Differentiation into lymphoid stem cells in the thymus
 - General T cells mature in the thymus
 - Migration of mature general B and T cells



- Secondary lymphoid organs: lymph nodes, spleen, tonsils, external body surfaces (intestinal, respiratory, urinary reproductive)
- d. Immune activation and response
 - What triggers these cells to respond?
 - Antigen-antibody binding
 - Structure, location and function (tag and disable antigens, alert T cells, macrophages, leukocytes of presence of antigens) of antibodies
 - B cells- recognize antigens, proliferate and produce specific antibodies.
 - Differentiate into plasma cells to produce more antibodies
 - Differentiate into memory cells- in supply for activation from second encounter by same antigen
 - T cells- recognize and destroy tagged antigens and proliferate
 - Cytotoxic T- bind to antigen on plasma membrane of target cells and directly destroy the cells
 - Helper T- help activate B cells, cytotoxic T cells, natural killer cells and macrophages
 - Remaining cells can respond to secondary exposure
- e. *Use supplemental homework/guided lecture notes worksheet (Appendix C) [Download worksheet](#)*

2. PowerPoint presentation with lineage tree reference: Natural Killer Cells- where do they fit in?

PowerPoint slides [Download Natural Killer Cell PowerPoint here](#)

- a. Note placement of natural killer cells in tree. Teacher explains role of natural killer cells from background information section.
 - NK cells make up 10-15% of the circulating lymphocytes in the adult
 - Exact physiological roles are unclear; they may be able to
 - recognize and destroy cancer cells and cells infected with certain kinds of viruses.
 - They do not use the same gene rearrangement mechanism as other lymphocytes (they seem to be more primitive WBCs)
 - When other lymphocytes are prevented from developing in



experimental mice, NK take over the job of the other WBCs

b. In groups, students decide if NK cells would be considered a part of nonspecific or specific immunity

- Use following site to try to make a decision [Natural Killer Cell article](#)
- Can also make this a webquest in-class or homework assignment so groups can come up with evidence

c. Each group makes a decision and gives evidence for and against their conclusion in oral presentation.

- “NK cells are sometimes considered to be one of the innate immunity mechanisms, because it is unclear how or whether these cells develop responses to specific stimuli.” (Dee, Puleo, Bizios, 2002)

Images to reinforce or accompany lecture:

<http://visualsonline.cancer.gov/retrieve.cfm?imageid=7149&dpi=72&fileformat=jpg>
(stem cell lineage tree- condensed)

<http://visualsonline.cancer.gov/retrieve.cfm?imageid=7150&dpi=72&fileformat=jpg>
(stem cell lineage tree- expanded)

<http://visualsonline.cancer.gov/retrieve.cfm?imageid=7142&dpi=72&fileformat=jpg>
(types of blood cells)

<http://visualsonline.cancer.gov/retrieve.cfm?imageid=7154&dpi=72&fileformat=jpg>
(lymph system)

III. APPLICATION

A. Challenging the Immune System: diagnosis and understanding

Students encounter a personal perspective as they learn about blood disorders through the eyes of the patient using one of four case studies in Appendix D

Download case studies: [leukemia](#), [lymphoma](#), [sickle cell anemia](#), [HIV/AIDS](#)

1. In groups of 4, students take on the case of one patient having one of the following disorders: leukemia, lymphoma, sickle cell disease and HIV/AIDS.

- Use supplemental handouts if desired - symptoms, diagnostic results such as Complete Blood Count (CBC), explanation of disease, etc.



2. Read case study and answer questions in groups. Finish for homework if students need more time or need to use the internet for gathering more information.

3. Next day: students meet in jigsaw teaching groups and then explain their cases to groups (here, students are playing the role of doctor). While students learn about each disease in their teaching groups they fill out Download Appendix E: [Blood Disorder Summary Table - student handout and teacher version](#).

4. Final assessment: students turn in their final copy of summary table.

B. Bone marrow transplants. After learning about various disorders, students explore the option of bone marrow transplants and compare it to other forms of treatment.

1. Watch Animation/Tutorials:
[Bone Marrow Transplant animation](#) AND [Bone Marrow or Stem Cell Transplants](#)

2. Answer these questions

- What are the patient's options?
- What is a bone marrow transplant? How does it work? What are the critical cells that are needed? Refer back to cell lineage tree.
- What are the dangers of bone marrow transplant (immune rejection)?
- Compare tissue typing (HLA) to blood typing

3. Extensions/homework activities

- a. See lesson [Bone Marrow Lesson](#)
- b. Explain How Umbilical Cord Blood and Bone Marrow Used? [NWABR Stem Cell Lesson](#) (pages 63/64)

OR:

c. After completing case studies, have students Jigsaw or read as homework, these "Science Daily" articles for each matching case study

Leukemia:

Download here [Leukemia](#)



AIDS:

Download here [AIDS](#)

Sickle Cell:

Download here [Sickle Cell](#)

Lymphoma:

Download here [Lymphoma](#)

OR:

d. Show freely-available educational videos

i. Webquest with students and watch videos on various Bioscience careers

[Careers](#)

ii. View these videos and share in discussion-

A number of educational videos are available by the American Society for Hematology that explain blood functions and disorders, what hematology is and what hematologists do, why students may want to consider choosing hematology as their specialty, and the importance of biomedical research.

[Hematology videos](#)

iii. Discover research topics-North Carolina Association for Biomedical Research video “Living Proof: Faces of Research” and accompanying teacher resources

[Download research topics](#)

IV. ASSESSMENT:

A. Students browse normal, leukemic, and sickle cell blood smear samples and sketch/compare differences in cell morphology between the samples.

B. Teacher design questions to test understanding of lecture topics and concepts behind each disease.



C. Students turn in final copy of Blood Disorder Summary Table

Materials: Human blood smear slides: normal, leukemia, sickle cell disease (WARDS: Acute Lymphatic Leukemia slides #93 V 9040, WARDS: blood pathology set #95 V 2639, Carolina: Sickle Cell Anemia Smear #317374)

OR

<http://www.bloodthevitalconnection.org/for-students/tools.aspx#PowerPoint>

Additional Resources:

<http://visualsonline.cancer.gov/> Browse topic you desire

LYMPHOMA

American Cancer Society website:

Hodgkin

<http://www.cancer.org/Cancer/HodgkinDisease/DetailedGuide/hodgkin-disease-what-is-hodgkin-disease>

Non-Hodgkin

<http://www.cancer.org/Cancer/Non-HodgkinLymphoma/DetailedGuide/non-hodgkin-lymphoma-what-is-non-hodgkin-lymphoma>

Diagnosing lymphoma

Hodgkin

<http://www.cancer.org/Cancer/HodgkinDisease/DetailedGuide/hodgkin-disease-diagnosis>

Non-Hodgkin

<http://www.cancer.org/cancer/non-hodgkinlymphoma/detailedguide/non-hodgkin-lymphoma-diagnosis>

Treating H lymphoma

<http://www.cancer.org/Cancer/HodgkinDisease/DetailedGuide/hodgkin-disease-treating-by-stage>

LEUKEMIA

The Leukemia and Lymphoma Society

Leukemia

http://www.leukemia-lymphoma.org/all_page.adp?item_id=7049

Chronic Myelogenous Leukemia (CML)

<http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/CML.html>



SICKLE CELL ANEMIA

NIH

Sickle Cell Anemia genetics and tests

<http://www.genome.gov/page.cfm?pageID=10001219>

US Nat Library of Medicine and NIH

Lots of info here:

<http://www.nlm.nih.gov/medlineplus/sicklecellanemia.html> - cat46

Mayo Clinic Website

Sickle cell Anemia Symptoms

<http://www.mayoclinic.com/health/sickle-cell-anemia/DS00324/DSECTION=symptoms>

HIV

CDC website

<http://www.cdc.gov/hiv/topics/basic/index.htm> - hiv

Symptoms

<http://www.cdc.gov/hiv/resources/qa/qa5.htm>

NIH

Treatment, prevention, and research

<http://www.aidsinfo.nih.gov/>

HIV anti-retroviral treatments

<http://www.nlm.nih.gov/medlineplus/ency/article/000594.htm>

AIDS Treatment guidelines (LONG and difficult pdf, has specific facts about treating the manifestations of AIDS)

<http://www.cdc.gov/mmwr/pdf/rr/rr5804.pdf>

Hematopoietic stem cell information

Other uses of hematopoietic stem cells (examples of clinical trials)

http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.cellbio.22.010605.093317?url_ver=Z39.88-2003&rft_id=ori:rid:crossref.org&rft_dat=cr_pub=ncbi.nlm.nih.gov

Recent modification to stem cell lineage tree?? Discovery by Hiroshi Kawamoto (**AP appropriate**) <http://www.rikenresearch.riken.jp/frontline/717/>